

10/526200
PCT/IB 03/03807
01.10.03



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Patentanmeldung Nr. Patent application No. Demande de brevet n°

02078674.5

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Anmeldung Nr:
Application no.: 02078674.5
Demande no:

Anmeldetag:
Date of filing: 06.09.02
Date de dépôt:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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Mercury free metal-halide automotive burner with ceramic envelope

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s)
revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

H01J61/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of
filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

Mercury free metal-halide automotive burner with ceramic envelope

EPO - DG 1

06. 09. 2002

Full description of the invention, covering items a) to f)

a) What was known on the subject, and from what source?

(75)

b) What are the drawbacks of this?

c) What is your proposal?

5 d) To what extent has it been realised so far?

a) Metal halide lamps in pca contain a rare gas as starting gas, metal halides for luminous efficacy and color quality and mercury mainly to increase the electric field strength. It is attractive to replace Hg by another more environmental friendly element. In patent WO 99/05699 (inventors: Born, Jost en van Vroonhoven) such a mercury free lamp in ceramic envelope (with Zn or ZnI₂ instead of Hg) has been described for general lighting.

15 b) The under a) mentioned patent is limited to pca lamps with Zn or ZnI₂ filling, complying the relation $1 \leq EA/Di \leq 4$. These lamps are normally short and thick but might also be long and thin (if EA/Di is close to 4).

However CDM automotive lamps should be even thinner than the above mentioned limit to create beam patterns in complex shape reflectors meeting the requirements. For this very specific application nor the pca burners as claimed in patent WO 99/05699 nor the present Quartz D2R automotive lamps can be used.

20 Also the claimed amount of ZnI₂ is limited to 20 $\mu\text{mol}/\text{cm}^3$ and the RE filling to 40 $\mu\text{mol}/\text{cm}^3$. With these amounts of ZnI₂ and salts CDM automotive lamps, with their very specific temperature distribution along the tube wall and their relatively large gaps between electrode feedthrough and extended plug, cannot be realized with a sufficiently high luminance and a sufficiently high lamp voltage.

25 A high luminance and thus high luminous flux out of an arc with a predefined arc length is necessary to meet the beam requirements. A high V_{la} is necessary to keep the lamp current low and thus the full electronic ballast cheap.

Beside that, if a Hg free automotive burner would be made just by increasing EA/Di (larger than 4) and the amount of ZnI₂ and RE filling, also no applicable lamps would be obtained. In that case we would encounter the following problems:

Problem 1: The lamp voltage would be too low.

- 5 In a lamp (with a predefined electrode distance of 4-5 mm) decrease of Di or increase of the amount of ZnI₂ can still lead to a too low coldest spot temperature to obtain a sufficiently high ZnI₂ (and RE) pressure and thus lamp voltage. To achieve in such a burner a lamp voltage > 50 V a coldest spot temperature > 1250 K will be necessary.

- 10 For optimised electronic circuits (small and cheap) a lamp voltage larger than 50 V is preferred, especially if a future board voltage of 42 V is taken into account.

Problem 2: The luminance would be too low

Increase of the ZnI₂ amount leads to a lower luminous flux and thus lower luminance.

Problem 3: The maximum wall temperature (upper side of tube) would be too high (> 1700 K).

- 15 Increase of the ZnI₂ amount leads to a higher wall temperature due to a less efficient plasma and an increased heat conduction to the tube wall.

Also decrease of the inner diameter (Di) in an automotive pca burner with an electrode distance between 4 and 5.5 mm leads to a strong temperature increase in the middle of the tube especially in comparison with the 'present' Hg burners (geometry as indicated in figure

20 1).

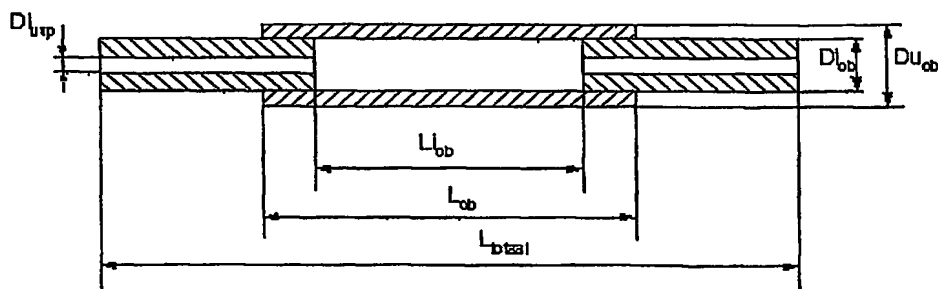


Figure 1 Geometry of 'standard Uden' pca tubes for Hg filled automotive burners.

Dimensions: Duob = 2.0 mm, Diob = 1.4 mm, Liob = 8.0 mm, Lob = 10.0 mm, wt = 0.3 mm,

25 Ltotaal = 24.0 mm, DiVUP = 0.56 mm.

Problem 4: The temperature difference between the maximum wall temperature at the upper end lower side of the burner (ΔT) would be too large.

A higher amount of ZnI₂ amount leads to narrowing of the arc, a larger curvature due to convection and thus to a larger ΔT .

- 5 c) The proposal, to solve these technical problems, is to make Hg-free ceramic burners with specially adapted tube dimensions and filling:

Tube dimensions: - $2 < EA/Di < 8$ (extremely thin tubes)
 - $Wt/Di > 0.2$ (relative thick wall in comparison with the thin internal diameter to control the maximum wall temperature and the wall temperature difference between top and bottom of the horizontal burning burner)

10 - $L_{lob} < 8 \text{ mm}$ (to create a sufficiently high coldest spot temperature (T_{cs}) to achieve a sufficiently high ZnI₂ pressure and salt pressure, necessary for respectively a high V_{la} and high luminance)

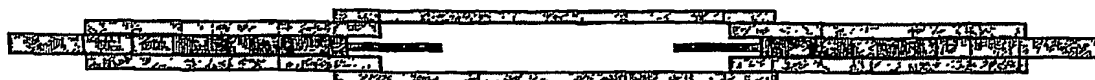
15 - $L_{ob} > 9 \text{ mm}$ (to keep the cooling surface to the surrounding sufficiently large)

Filling: - $20 \mu\text{mol/cm}^3 < \text{amount of ZnI}_2 < 140 \mu\text{mol/cm}^3$
 - Amount of RE iodide $> 40 \mu\text{mol/cm}^3$
 - $5 \text{ bar} < P_{xe} < 25 \text{ bar}$

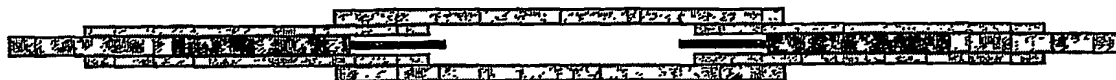
20 Beside that it is proposed as advantageous to achieve further improvement:

- to apply coatings on tube and/or inner side of outer bulb to increase further the coldest spot temperature
- to apply a gas filled outer bulb close to the tube wall to reduce the maximum temperature in the middle of the tube

30 d) A lot of work has been put in the development of these CDM Hg free burners, which meant solving all the under b mentioned problems. The most recent Hg free 30W prototype has an aspect ratio EA/Di of 4.2 ($ea = 5.0 \text{ mm}$ and $Di = 1.2 \text{ mm}$; further relevant dimensions: see figure 2 and table 1) and is filled with: 16 bar Xe, 0.6 mg NaPrI and 0.1-0.2 mg ZnI₂.



a.



5 b.

Figure 2 Old Hg filled (a) and new Hg free (b) optimised tubes of 30W Hg free CDM automotive burners.

10 Old: wt = 0.3 mm, Diob = 1.4 mm, Liob = 8 mm

New: wt = 0.4 mm, Diob = 1.2 mm, Liob = 6 mm

Table 1

Parameter	[mm]
Duob	2.0
Diob	1.2
Liob	6.0
Lob	10.0
Ltotaal	24.0
Divup	0.54
Duvup	1.2

15 Table 1: PCA dimensions of most recent 30W Hg free CDM automotive prototype burner

Problem 1, the too low lamp voltage, has been solved by:

- increasing the Xenon pressure up to 16 bar (even higher pressures are preferred but are difficult to be realised).
- 20 - shortening Liob up to 6 mm, which leads to a higher Tcs and thus higher ZnI₂ and NaPr iodide pressure and thus lamp voltage.
- decreasing the internal diameter up to 1.2 mm, leading to an additional lamp voltage increase

With these measures lamp voltages up to 90-95 V have been achieved. This is very attractive
 25 for small and cheap full electronic ballasts. For comparison with D4 quartz Hg free lamps only lamp voltages of 40 V can be achieved

Problem 2, the too low luminance, has been solved by:

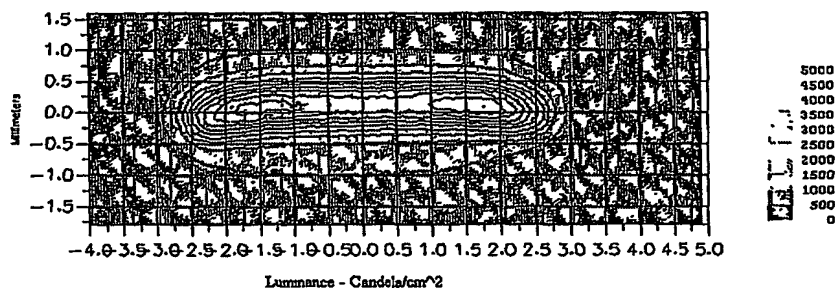
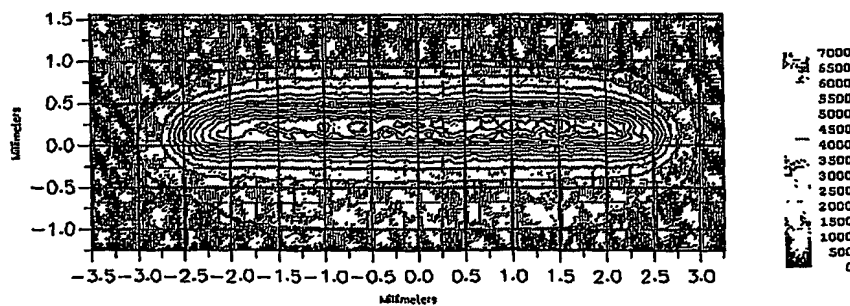
- increasing the Xenon pressure up to 16 bar (even higher pressures are preferred) which leads to a more constricted and slightly more efficient arc and thus higher luminance.

- shortening Liob, which leads to a higher Tcs and thus higher NaPr iodide pressure and thus higher luminous flux.

- increasing the lamp wattage (from originally 26 W for Hg filled burners to 30W for Hg free burners)

- choosing a sufficiently large amount of RE iodide (about 0.6 mg) to avoid disappearing of too much salt in the "cold" gap between electrode and extended plug.

With these measures the luminance has been increased from 55 Mcd/m² up to 78 Mcd/m² for a 30 W burner in the middle of the arc (see figure 3). This is already very close to the comparable D4 35W Hg free quartz lamps (87 Mcd/m²).

Luminance - Candela/cm²Luminance - Candela/cm²

X: .000; Y: .000; Value = 0.000

Luminance - Candela/cm²

5

Figure 3 Luminance distributions of Hg free burners in:

- 10 a) a pca envelop with Diob = 1.4 mm, Liob = 8 mm and PXe = 8 bar (30W)
 b) a pca envelop with Diob = 1.2 mm, Liob = 6 mm and PXe = 16 bar (30W)
 c) a quartz envelope (D4 prototype; April 2002; M. Haacke, Rhote Erde Aachen (35W))

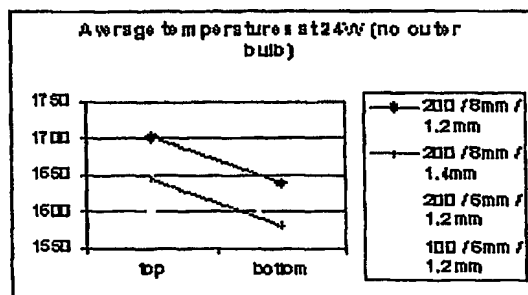
15 Problem 3, the too high maximum wall temperature, has been solved by:

- increasing the wall thickness from 0.3 up to 0.4 mm (the outer tube diameter stays 2 mm) leading to a higher heat transport to the tube ends
- keeping the outer surface of the arc tube the same (Lob = 10 mm; Duob = 2 mm) for constant cooling to the direct environment while at the same time Liob is simultaneously
- 20 decreased.
- Lowering the ZnI₂ amount to 0.1-0.2 mg (45-90 $\mu\text{mol}/\text{cm}^3$) which leads to a small drop in V_{la} but also to an increase of the visible Watts and thus a decrease in wall temperature

With these measures the maximum wall temperature has been kept at about 1700 K, in spite

25 of the fact that the lamp power has been increased from 26 to 30 W.

An indication of the effects of the changes in dimensions and ZnI₂ amount is illustrated in figure 4. In this figure the averaged (n=3) maximum temperatures (K) of the upper and lower

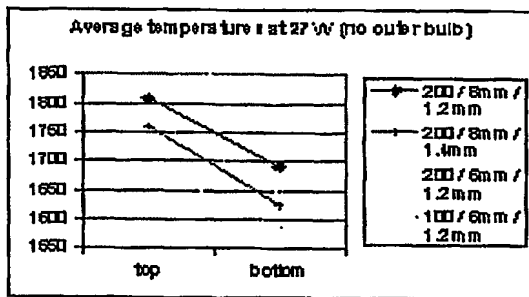


thickness of .4 mm without outer bulb on a constant
 3) ZnI₂ / Liob (mm) / Diob (mm)). The temperature
 the outer bulb can here of course not be taken into
 tures cannot be measured through a the surrounding

Figure 4 The averaged ($n=3$) maximum temperatures (K) of the upper and lower wall for burners (NaPr iodide; 8 bar Xe; ZnI₂) without outer bulb at 24 and 27W.

5

Problem 4, the too high temperature difference between the maximum wall temperature at the



upper end lower side of the burner (ΔT) has been solved by:

- increasing the wall thickness wt from 0.3 to 0.4 mm
- decreasing the internal diameter leading to a straighter arc (less bending) and thus to a better T homogenisation between upper and lower side of the tube.

10

With these measures ΔT can be decreased or at least be kept smaller than 150 K which is generally considered as a critical limit for cracks in pca lamps.

Table 2 shows the discharge tube dimensions (PCA dimensions)

15

Figure 4 shows the relation between metallic zinc or zinc-iodide dose and the lamp voltage.

Table 3 shows the electrical and lighttechnical results of 2 lamps after 20 burning hours.

Table 2: PCA dimensions

Parameter	[mm]
Duob	2.0
Diob	1.4
Liob	8.0
Lob	10.0
Ltotaal	24.0
Divup	0.54
Duvup	1.35

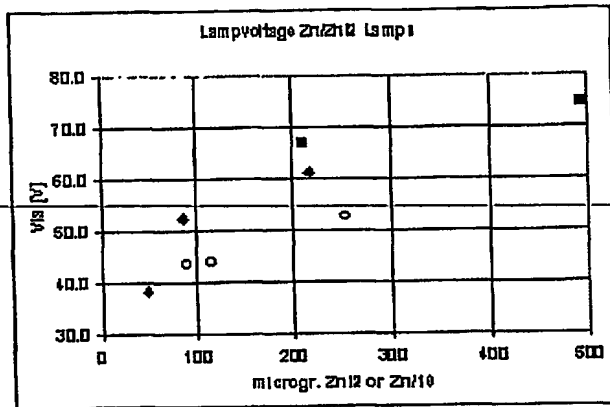


Figure 2 Lamp voltage as function of amount Zn or ZnI2

▪ ZnI2 with coating

5 ♦ ZnI2 without coating

○ Zn without coating

Table 3 Electrical and lighttechnical properties of Hg free pca burners (20 hours, OCM)

	Lamp 573	Lamp 574
Pla [W]	26	26
Vla [V]	67	74.6
Luminous flux[Lm]	1577	1168
x	.430	.393
y	.389	.362
CCT [K]	2987	3549
CRI	51	61
remarks	Wall blakening	Wall blakening

10

Not stable lamp

These results show that at least attractive lamp voltages can be realised. Further investigations are executed.

15 Ceramic in this description and claims means gas tight densely sintered polycrystalline metal oxide, like for example alumina, gas tight densely sintered metal nitride, like for example

AlN, mono crystalline metal oxide like sapphire. These materials can be made translucent by common techniques.

CLAIMS:

06. 09. 2002

(75)

1. High pressure discharge lamp provided with a discharge tube having a ceramic wall and which tube has an ionizable filling being free of mercury (Hg).

2. Lamp according to claim 1, having an aspect ratio EA/D_i between 2 and 8.

3. Lamp according to claim 3, having a ratio wall thickness versus inter diameter Wt/D_i which is > 0.2 .

4. Lamp according to claim 1, having an discharge tube internal length $Liob < 8mm$.

5. Lamp according to claim 1, having discharge tube length $Lob > 9mm$.

6. Lamp according to claim 1, the filling comprising ZnI_2 in an amount of at least $20\mu mol/cm^3$ and at most $140\mu mol/cm^3$.

7. Lamp according to claim 1, the filling comprises an amount of RE iodide $> 40\mu mol/cm^3$.

8. Lamp according to claim 1, the filling also comprising Xe with a fill pressure P_{xe} of at least 5 bar and at most 25 bar.

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